CORPS OF ENGINEERS, U. S. ARMY

HYDRAULIC CAPACITY OF MEANDERING CHANNELS IN STRAIGHT FLOODWAYS

HYDRAULIC MODEL INVESTIGATION

CWI ITEM NO. 807
HYDRAULIC CAPACITY OF MEANDERING CHANNELS

TECHNICAL MEMORANDUM NO. 2-429

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PREFACE

The investigation, CWI No. 807, "Hydraulic Capacity of Meandering Channels," was conducted by the Waterways Experiment Station as part of the Civil Works Investigations program of the Office, Chief of Engineers. This study was authorized by the latter office in a second indorsement, dated 6 January 1948, to Waterways Experiment Station letter, dated 7 November 1947, subject: "Hydraulic Program - Engineering Investigation for Civil Works."

Liaison was maintained during the course of the investigation by progress reports and conferences. Mr. John C. Harrold, of the Office Chief of Engineers, visited the Waterways Experiment Station at various times in connection with the study.

The investigation was conducted during the period January 1948 to January 1955 under the supervision of Messrs. E. P. Fortson, Jr., and G. B. Fenwick, of the Hydraulics Division. In direct charge of the project was Mr. E. B. Lipscomb, who prepared this report.

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SUMMARY

The investigation reported herein was conducted for the purpose of isolating the various factors affecting floodway capacities. Specific objectives were to determine the effects on floodway capacity of: (a) radius of curvature of bends; (b) sinuosity of channel; (c) depth of overbank flow; (d) ratio of overbank area to channel area; and (e) overbank roughness.

Typical channel and floodway conditions were reproduced in a 100- by 30-ft flume. Two floodway widths, three depths of overbank flow, and three degrees of roughness were used in testing channels of various degrees of sinuosity and various meander-belt widths.

It was concluded from the results of the investigation that:

- a. Where the floodway channel is relatively narrow (and small) compared to the floodway width, the effect of sinuosity of channel on floodway capacity is small.
- b. In the case of the 2-ft-wide channel and a 16-ft-wide floodway the effects of increasing the channel sinuosity on floodway capacity becomes a critical factor.
- c. When the floodway width exceeds the meander-belt width by about 300 per cent, the effect of channel sinuosity on floodway capacity becomes relatively small.
- d. Channel discharge is reduced about 8-10 per cent by increasing the channel sinuosity from 1.20 to 1.40 and from 1.40 to 1.57.

HYDRAULIC CAPACITY OF MEANDERING CHANNELS IN STRAIGHT FLOODWAYS

Hydraulic Model Investigation

PART I: INTRODUCTION

1. Streams in their natural state tend to meander within their flood plains, following a sinuous course of irregular bends and loops. This tendency to meander results in certain changes in the physical characteristics that affect the discharge capacities of the streams. It is reasonable to assume that, since the capacity of a stream is affected and since the flow within the channel is not always parallel to the axis of the floodway, the hydraulic capacity of the floodway is affected to some extent by the degree of meandering. Also, there is reason to believe that in certain cases the effect of a sinuous channel on floodway capacity may be relatively large and therefore greatly influence the floodway design.

2. Meandering channels have varying characteristics such as ratio of channel length to airline distance (designated herein as sinuosity ratio), width and depth of channel, curvature of bends, and width of meander belt. These characteristics together with the variable characteristics of the floodway, such as overbank undergrowth and surface irregularities and valley slope, are the principal factors tending to affect, in varying degrees, the hydraulic capacity of a floodway.

3. This report describes an investigation conducted for the purpose of isolating the factors affecting floodway capacities. The specific objectives of the investigation were to determine, by means of model tests, the effects of each of the following factors on floodway capacity: (a) radius of curvature of bends; (b) sinuosity of channel; (c) depth of overbank flow; (d) ratio of overbank area to channel area; and (e) overbank roughness.

PART II: THE MODEL

Design Considerations

4. Since the investigation was of a general nature, no attempt was made to reproduce a specific stream or floodway. However, it was deemed advisable for all the hydraulic and physical elements in the model to be generally proportionate to average conditions in nature so that the data obtained could be applied to field problems.

5. As the preliminary step in determining feasible and appropriate dimensions for the model testing flume, an extensive study was made of prototype meander patterns involving changing sinuosities and radii, since these two variables, together with depth of overbank flow, were believed to be of primary concern in the model study. Some pertinent facts revealed by this research and given consideration in the design of the test flume are listed below:

- a. The limit for the width of the meander belt of any given stream is, in general, about 18 times the mean width of the stream, the effects of depth of water and volume of stream discharge on meander-belt width being negligible.
- b. Streams rarely attain their maximum width of meander until the belt is two to three times as wide as the successive loops are distant along the general course of the river.
- c. The larger the volume of water discharged by a river, the wider is its meander belt, but the increases in width are proportionately less as the volume of the river becomes greater.
- d. The width of a meander belt depends directly upon the sharpness with which a stream traverses a bend. Generally speaking, the longer the radius of curvature, the wider the belt; the shorter the radius, the narrower the belt.

Experimental Apparatus

6. Tests were conducted in a flume 100 ft long by 30 ft wide (see fig. 1) in which typical channel and floodway conditions were reproduced. The channel and floodway areas were molded in sand and covered with a veneer of concrete about 0.1 ft thick for stability. The floodway width

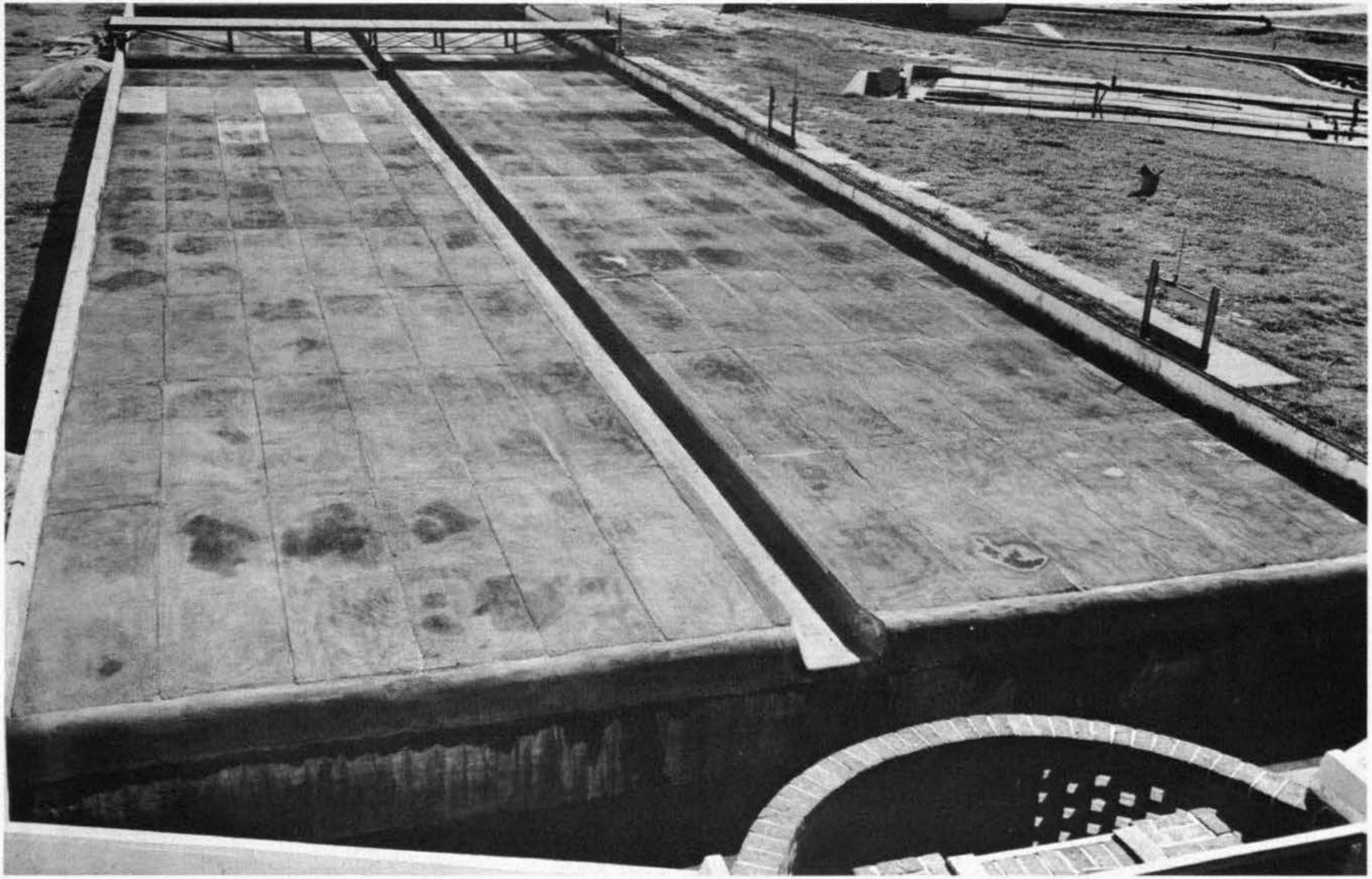


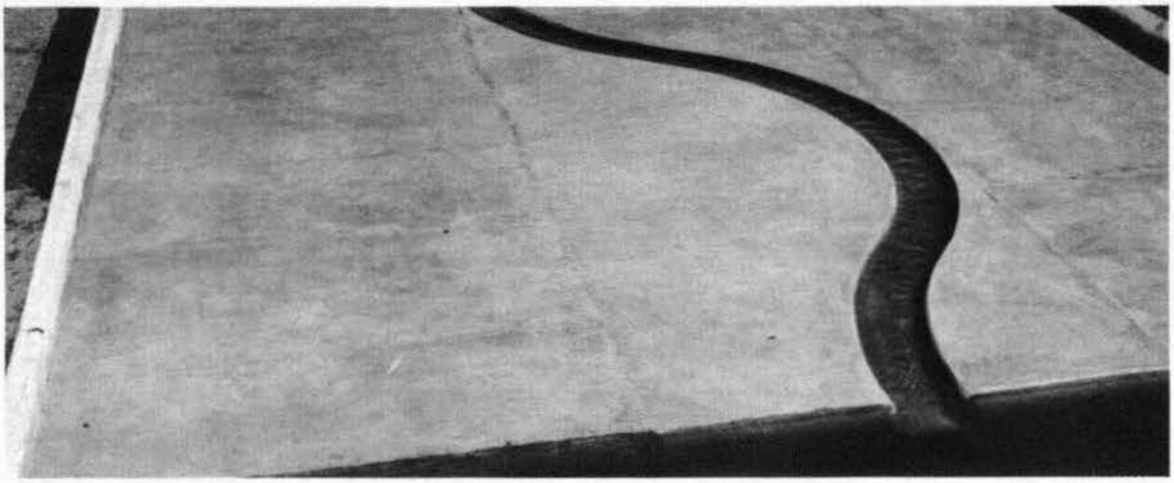
Fig. 1. Flume used for study with straight model channel in center

Fig. 2. Floodway width was varied by means of brick walls; here, it is 16 ft

was varied by installing temporary brick walls in the overbank area (see fig. 2). Flow through the flume was measured with a sharp-edged rectangular weir 4 ft wide. Water-surface slopes were controlled by an adjustable tailgate. Water-surface elevations were measured by means of piezometers placed in transverse lines at 10-ft intervals along the length of the flume. There were three piezometers in each line, one located on the center line of the straight channel and the other two on the floodway overbank, one on each side of the channel.

Floodway Roughness

7. As the roughness of the floodway overbank was considered to be one of the variable factors affecting floodway capacity, provisions were made for varying its intensity by use of three different materials as shown in fig. 3. These materials and the values of "n" (Manning's)



Brushed concrete, n = 0.012

Expanded metal with long dimension parallel to flow, n = 0.025

Expanded metal with long dimension normal to flow, n = 0.035

Fig. 3. Materials used to represent 3 degrees of overbank roughness

determined for each were: (a) brushed concrete, 0.012; (b) expanded metal with the long dimension of the opening parallel to the flow, 0.025; and (c) expanded metal with the long dimension normal to the flow, 0.035. The expanded metal used for artificial roughness is commercially designated as Diamond Metal Lath, Wheeling 2.5 Bantam. A close-up of this material is shown in fig. 4.

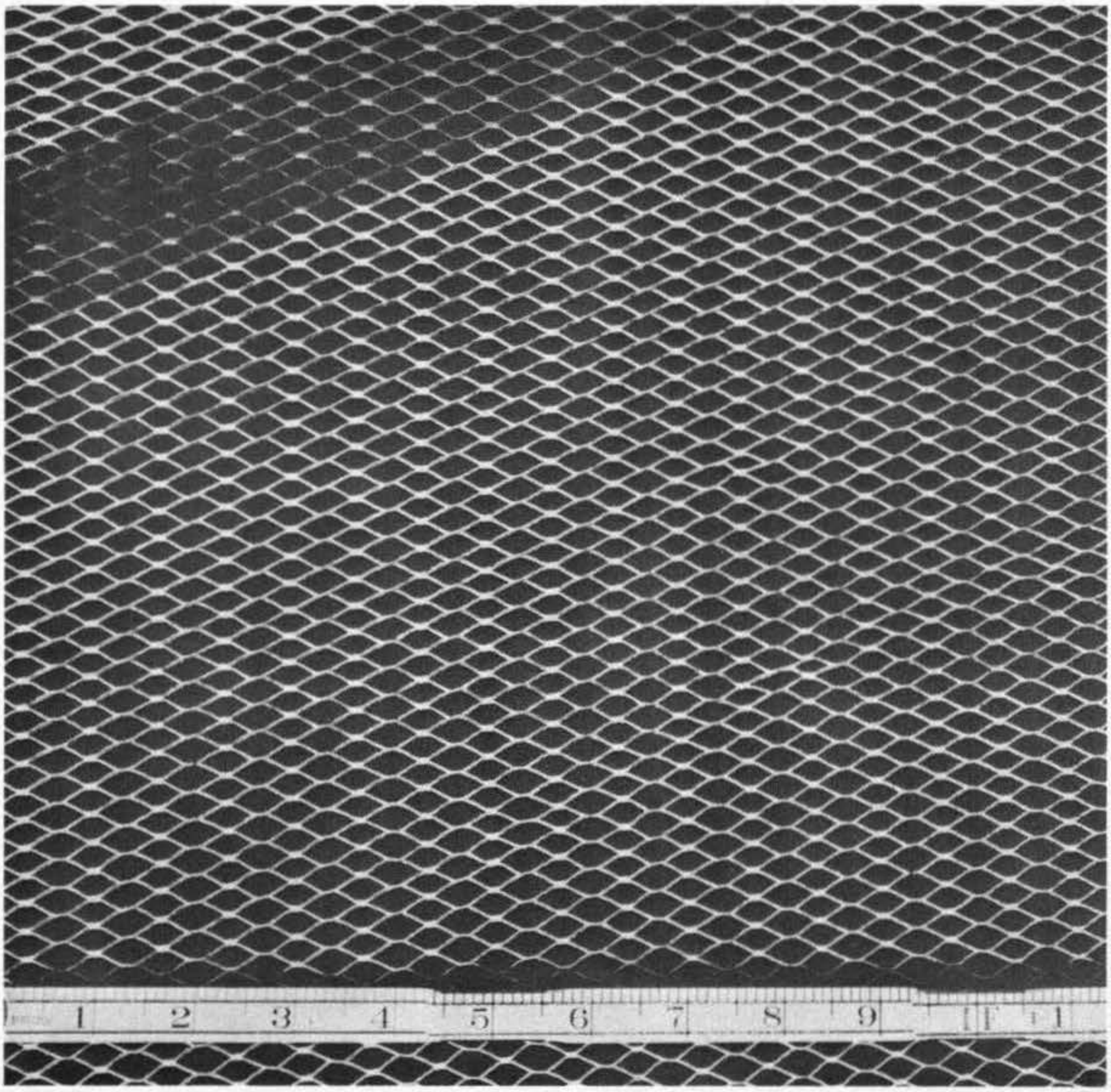


Fig. 4. Expanded metal used for artificial roughness

PART III: TESTS AND RESULTS

General Operating Procedure

8. The general procedure followed in operation of the flume consisted of first installing a straight channel along the center line of the floodway, which was either 16 ft or 30 ft in width. With the overbank and channel roughness the same (brushed concrete, "n" 0.012), the floodway discharges required to produce a bankfull flow and overbank flows of 0.1-ft, 0.2-ft, and 0.3-ft depths were determined. In all tests the valley slope and water-surface slope were maintained at 0.001. This procedure was repeated with the overbank roughness increased to 0.025 and 0.035. Channels having various degrees of sinuosity were then installed in the flume and the same general procedure was repeated for each channel sinuosity and the two floodway widths.

Tests of 1-ft-wide Channel

9. A trapezoidal channel having a bottom width of 1.0 ft, a top width of 1.5 ft, a depth of 0.5 ft, and a cross-sectional area of 0.625 sq ft was utilized in this series of tests. Thirteen different meander patterns were investigated using floodway widths of 16 ft or 30 ft. Dimensions of the meander patterns are tabulated below:

Test No.	Floodway Width ft	Sinuosity	Meander-belt Width, ft	Radius of Curvature ft
I	30	1.0	1.5	0
II	30	1.33	10.0	6
IIa*	30	1.255	10.0	6
III	16	1.33	10.0	6
IIIa**	16	1.255	10.0	6
IIIb*	16	1.255	10.0	6
IV	30	1.22	10.0	8

(Continued)

* Cutoff across second bend.
** Cutoff across first bend.

Test No.	Floodway Width ft	Sinuosity	Meander-belt Width, ft	Radius of Curvature ft
V	30	1.17	10.0	10
VI	16	1.17	10.0	10
VII	30	2.54	20.0	6
VIII	30	1.49	16.0	6
IX	30	1.50	20.0	10
X	30	1.75	20.0	8

10. The results of these tests are presented in table 1. One of the typical plots of the test data is included as plate 1. Here, the total floodway discharge is plotted against depth of overbank flow for a constant overbank roughness and various degrees of sinuosity of the floodway channel. Although these curves show a trend toward a decrease in floodway discharge with an increase in channel sinuosity, the test channel was so small, as compared to the total floodway, that the effects of the various meander patterns are not considered of sufficient magnitude to indicate definite conclusions or to permit prediction of trends.

11. In view of the inconclusive results obtained with the 1-ft-wide channel, it was decided that subsequent tests would be made with a 2-ft-wide channel in order to accentuate the effects of channel sinuosity on floodway capacity.

Tests of 2-ft-wide Channel

12. The model layout for tests of the 2-ft-wide trapezoidal channel is shown on fig. 5. Meander patterns tested are described below:

Test No.	Floodway Width ft	Sinuosity	Meander-belt Width, ft	Radius of Curvature ft
XI	16	1.00	2.50	0.00
XII	16	1.57	14.50	6.00
XIII	16	1.40	12.34	6.12
XIV	16	1.20	9.26	7.01
XV	30	1.20	9.26	7.01
XVI	30	1.57	14.50	6.00

13. The results of the tests of the 2-ft-wide channel are presented in table 2. Various plots for determining the effects on floodway capacity of the different variable factors are shown on plates 2-12. The effects of each variable are discussed in the following paragraphs.

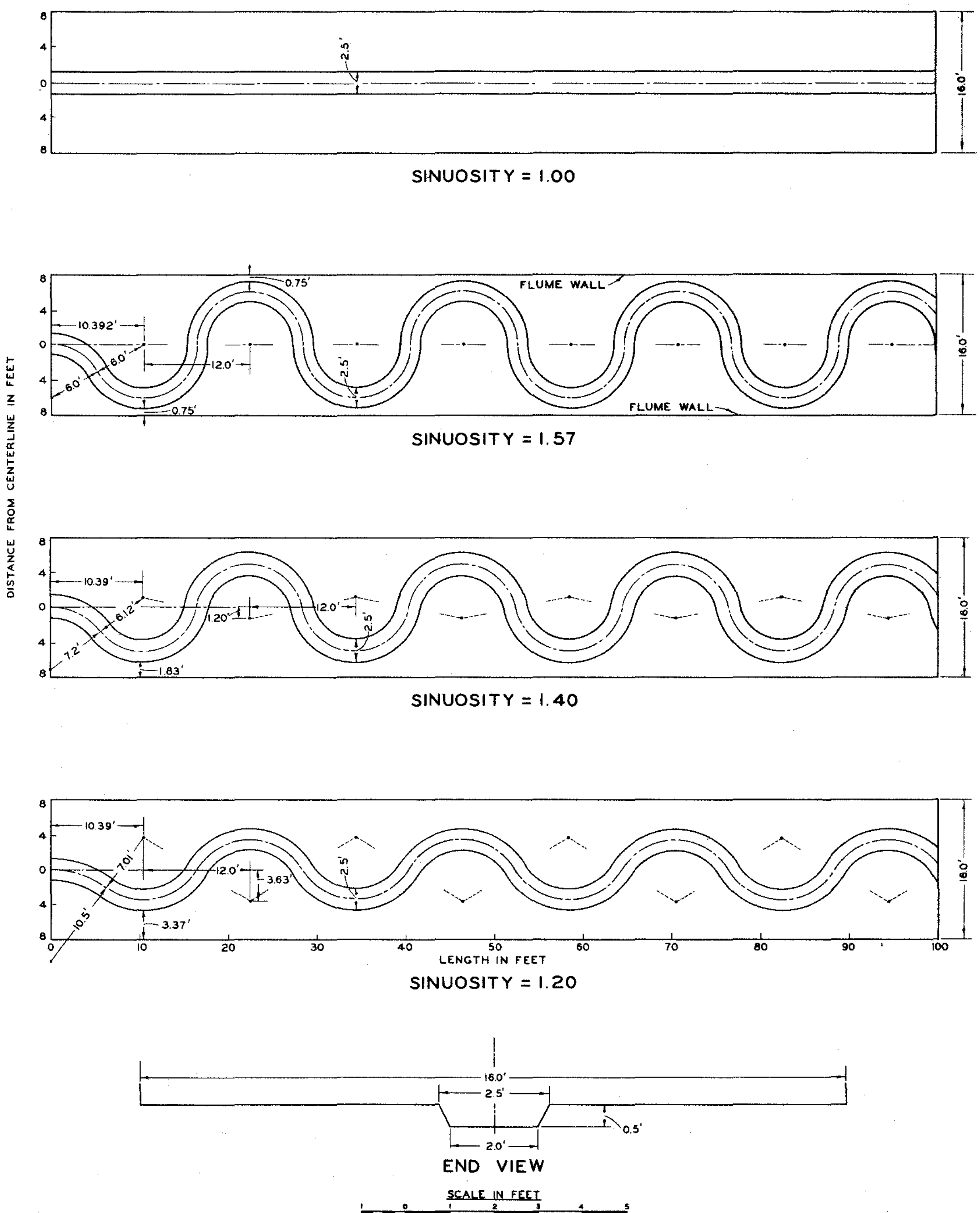


Fig. 5. Model layout for tests of 2-ft-wide channel

Sinuosity-floodway
discharge relationship

14. Effect of overbank flow depth. The relationship between channel sinuosity and floodway discharge for three overbank flow depths is presented on plate 2. Examination of these plates shows that for each

depth of overbank flow an increase in channel sinuosity decreases the floodway discharge. The shape of the curves indicates that the percentage reduction in floodway discharge due to increased channel sinuosity is about the same for each overbank flow depth. Computations of the actual percentages show reductions amounting to about 20 per cent for a sinuosity of 1.20 and about 35 per cent for a sinuosity of 1.57. The spread of the curves for the 0.1-, 0.2-, and 0.3-ft overbank flow depths indicates a slightly larger quantity reduction between the 0.2-ft and 0.3-ft depths than between the 0.1-ft and 0.2-ft depths.

15. Effect of overbank roughness. The relationship between channel sinuosity and floodway discharge for the three overbank roughness values and depths of flow is presented on plate 3. It will be noted from this plate that the decrease in discharge caused by increasing n from 0.012 to 0.025, as compared with the decrease in discharge caused by increasing n from 0.025 to 0.035, appears to be somewhat greater than would be indicated by application of the Manning equation alone. In an attempt to further analyze these data plate 4 was prepared. It will be noted that the three curves for the 0.1-ft depth fall in the expected order, but that at the 0.2-ft depth the curve for $n = 0.012$ falls between the two curves for $n = 0.025$ and $n = 0.035$, while for the 0.3-ft depth the curve for $n = 0.035$ falls between the other two.

Depth-floodway discharge relationship

16. Effect of channel sinuosity. Plots of the relationship between overbank depth and floodway discharge for various channel sinuosities are shown on plate 5. The same general conclusions can be drawn from these plots as from the plots on plate 2 discussed in paragraph 14. However, attention is directed to the spread of the curves shown on the lower plot of plate 5. It is noted here that for the high overbank roughness of 0.035, the increase in sinuosity from 1.00 to 1.20 affected the discharge much more markedly than did further increase in sinuosity from 1.20 to 1.40 and 1.57.

17. Effect of overbank roughness. Plots of the relationship

between overbank flow depth and floodway discharge for the three overbank roughness values are shown on plates 6 and 7.

Floodway and meander-belt width ratio-discharge relationship for overbank flow depths

18. The relationship between the floodway width and meander-belt width ratio and the floodway discharge for the three overbank flow depths is shown on plate 8. These plots indicate that as the meander-belt width approaches the floodway width the floodway discharge decreases.

Depth-discharge relationship for two floodway widths

19. The relationship between depth of overbank flow and floodway discharge as affected by a 2-ft-wide channel having sinuosities of 1.20 and 1.57 in 16-ft- and 30-ft-wide floodways is shown on plate 9. Examination of these curves indicates that the effect on floodway discharge of changing the channel sinuosity from 1.20 to 1.57 was about the same for the 16-ft-wide floodway as it was for the 30-ft-wide floodway. The percentage reduction in floodway discharge for the 16-ft-wide floodway was 11, 15, and 18 per cent at the 0.3-, 0.2-, and 0.1-ft depths as compared to corresponding reductions of 9, 15, and 25 per cent for the 30-ft-wide floodway.

Sinuosity-channel discharge relationship for overbank flow depths

20. All previous analyses of the test results were made on the basis of total floodway discharge; that is, with no distinction between the discharge in the main channel and that on the overbank. To provide a means for determining the effect of the different variables on the capacity of the main channel, a series of tests was run to obtain data on the capacity of the floodway without a channel. The overbank flow was then computed by the following equation:

$$Q_o = Q_f \left(\frac{W - t}{W}\right)$$

where W = width of flood plain (16 ft)

t = top width of channel (2.5 ft)

Q_f = floodway discharge without channel, cfs

Q_o = discharge on the overbank, cfs.

Then the main channel flow was determined as follows:

$$Q_m = Q_T - Q_o$$

where

Q_T = total floodway discharge (with channel), cfs

Q_m = main channel discharge, cfs.

A summary of the computations of the capacity of the main channel is presented in the following tabulation:

Summary of Computations of Capacity of Main Channel

Test Conditions				Sinuosity							
Manning's "n"	Depth (ft above Topbank)			1.00		1.20		1.40		1.57	
		Q_f*	Q_o†	Q_T‡	Q_m§	Q_T	Q_m	Q_T	Q_m	Q_T	Q_m
	0.0				2.22		1.55		1.38		1.22
0.012	0.1	1.42	1.20	4.02	2.82	3.23	2.03	2.93	1.73	2.48	1.28
0.012	0.2	4.31	3.64	7.73	4.09	6.33	2.69	5.51	1.87	5.03	1.39
0.012	0.3	7.98	6.74	12.50	5.76	9.79	3.05	8.58	1.84	7.88	1.14
	0.0				2.22		1.55		1.38		1.22
0.025	0.1	0.57	0.48	2.81	2.33	1.96	1.48	1.73	1.25	1.52	1.04
0.025	0.2	2.20	1.86	4.44	2.58	3.85	1.99	3.48	1.62	3.09	1.23
0.025	0.3	4.50	3.80	7.65	3.85	6.35	2.55	5.93	2.13	5.46	1.66
	0.0				2.22		1.55		1.38		1.22
0.035	0.1	0.37	0.31	2.74	2.43	1.71	1.40	1.55	1.24	1.40	1.09
0.035	0.2	1.53	1.29	4.28	2.99	3.05	1.76	2.94	1.65	2.59	1.30
0.035	0.3	3.19	2.69	6.32	3.63	5.07	2.38	4.85	2.16	4.53	1.84

* Q_f = Floodway discharge (cfs) without channel.
† Q_o = Discharge (cfs) on overbank.
‡ Q_T = Total floodway discharge (cfs) with channel.
§ Q_m = Discharge (cfs) in main channel.

21. The relationship between channel sinuosity and channel discharge for various overbank flow depths is presented on plate 10. Examination of this plate shows that for any given depth the discharge of the main channel decreases as the sinuosity of the channel increases. A comparison of the plot for an overbank n of 0.012 with the plot for an overbank n of 0.035 (plate 10) will show that as the overbank roughness increases the effect of changes in channel sinuosity on channel capacity decreases.

Effect of channel sinuosity on overbank flow depth-channel discharge relationship

22. Plots of the relationship between overbank flow depths and channel discharge for various channel sinuosities are shown on plate 11. These plots indicate that as the overbank flow depth increases the discharge of the main channel also increases. However, it is to be noted that as the sinuosity of the channel becomes greater, the increase in overbank flow depth begins to have a lesser effect on the capacity of the channel.

Reduction in channel discharge related to ratio of overbank and channel depths and areas

23. In considering the type plot that would be most useful to the engineer in applying the results of the model investigation to actual field problems, it was determined that a plot showing the percentage of reduction in channel discharge resulting from increases in the channel sinuosity as related to the ratio of overbank and channel depths and areas would be desirable. Plots presenting this information for the three values of overbank roughness are included on plate 12. Also shown on these plots is the value of the ratio of the width of meander belt to the width of the flood plain for each channel sinuosity tested.

24. Examination of these plots indicates that the channel discharge is reduced about 8-10 per cent by increasing the channel sinuosity from 1.20 to 1.40 and from 1.40 to 1.57. For overbank roughnesses of 0.025 and 0.035 the maximum decrease in channel discharge occurs when

the ratio of overbank flow depth to channel flow depth is about 0.25 and the ratio of overbank area to channel area is about 13.0. For the overbank roughness of 0.012 the reduction in channel discharge continued to increase for the range of conditions tested.

PART IV: CONCLUSIONS

25. It is believed that this hydraulic investigation accomplished its purpose of providing information regarding the effect of such variable factors as sinuosity, roughness, depth of overbank flow, etc., on the hydraulic capacity of a straight floodway. The principal indications derived from an analysis of the data obtained are as follow:

- a. Where the floodway channel is relatively narrow (and small) compared to the floodway width, the effect of channel sinuosity on floodway capacity is small.
- b. In the case of the 2-ft-wide channel and 16-ft-wide floodway, the effect of increased channel sinuosity on floodway capacity becomes a critical factor: increases in channel sinuosity from 1 to 1.20 and from 1 to 1.57 decreased the floodway capacity about 20 per cent and 35 per cent, respectively.
- c. When the floodway width exceeds the meander-belt width by about 300 per cent, the effect of channel sinuosity on floodway capacity becomes relatively small.
- d. Channel discharge is reduced about 8-10 per cent by increasing the channel sinuosity from 1.20 to 1.40 and from 1.40 to 1.57.

Table 1

Summary of Test Data, 1-ft-wide Channel

Test No.	Test Conditions	Manning's "n"	Depth (ft above Topbank)	Discharge cfs
I	Floodway width, 30.0 ft Sinuosity, 1.0 Meander-belt width, 1.5 ft Radius of curvature, 0.0 ft (straight channel)	0.012	0.0 (bankfull) 0.1 0.2 0.3	1.10 3.77 9.26 16.40
		0.025	0.1 0.2 0.3	2.20 5.66 10.58
		0.035	0.1 0.2 0.3	1.78 4.24 7.69
II	Floodway width, 30.0 ft Sinuosity, 1.33 Meander-belt width, 10.0 ft Radius of curvature, 6.0 ft	0.012	0.0 (bankfull) 0.1 0.2 0.3	0.86 3.10 8.55 15.30
		0.025	0.1 0.2 0.3	1.64 4.98 9.84
		0.035	0.1 0.2 0.3	1.31 3.73 7.22
IIa	Floodway width, 30.0 ft Sinuosity (same as test II with cutoff across second bend of channel), 1.255 Meander-belt width, 10.0 ft Radius of curvature, 6.0 ft	0.012	0.0 (bankfull) 0.1 0.2 0.3	0.96 3.37 9.08 16.14

(Continued)

Table 1 (Continued)

Test No.	Test Conditions	Manning's "n"	Depth (ft above Topbank)	Discharge cfs
III	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	0.86
	Sinuosity, 1.33		0.1	1.97
	Meander-belt width, 10.0 ft		0.2	4.80
	Radius of curvature, 0.6 ft		0.3	8.03
		0.025	0.1	1.06
			0.2	2.86
			0.3	5.42
		0.035	0.1	0.95
			0.2	2.26
			0.3	4.25
IIIa	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	0.98
	Sinuosity (same as test III		0.1	2.13
	with cutoff across first		0.2	5.28
	bend of channel), 1.255		0.3	8.85
	Meander-belt width, 10.0 ft			
	Radius of curvature, 6.0 ft	0.025	0.1	1.21
			0.2	3.10
			0.3	5.75
		0.035	0.1	1.05
			0.2	2.33
			0.3	4.44
IIIb	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	0.96
	Sinuosity (same as test III		0.1	2.10
	with cutoff across second		0.2	5.17
	bend of channel), 1.255		0.3	8.85
	Meander-belt width, 10.0 ft			
	Radius of curvature, 6.0 ft	0.035	0.1	1.11
			0.2	2.45
			0.3	4.47
IV	Floodway width, 30.0 ft	0.012	0.0 (bankfull)	0.91
	Sinuosity, 1.22		0.1	3.22
	Meander-belt width, 10.0 ft		0.2	8.63
	Radius of curvature, 8.0 ft		0.3	15.50
		0.025	0.1	1.70
			0.2	5.08
			0.3	9.85
		0.035	0.1	1.40
			0.2	3.99
			0.3	7.76

(Continued)

Table 1 (Continued)

Test No.	Test Conditions	Manning's "n"	Depth (ft above Topbank)	Discharge cfs
V	Floodway width, 30.0 ft	0.012	0.0 (bankfull)	0.93
	Sinuosity, 1.17		0.1	3.22
	Meander-belt width, 10.0 ft		0.2	8.72
	Radius of curvature, 10.0 ft		0.3	15.56
		0.025	0.1	1.69
			0.2	4.97
			0.3	9.69
		0.035	0.1	1.33
			0.2	3.49
			0.3	7.04
VI	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	0.93
	Sinuosity, 1.17		0.1	2.13
	Meander-belt width, 10.0 ft		0.2	5.15
	Radius of curvature, 10.0 ft		0.3	8.96
		0.025	0.1	1.23
			0.2	3.12
			0.3	5.79
		0.035	0.1	1.11
			0.2	2.43
			0.3	4.42
VII	Floodway width, 30.0 ft	0.012	0.0 (bankfull)	0.59
	Sinuosity, 2.54		0.1	3.28
	Meander-belt width, 20.0 ft		0.2	8.02
	Radius of curvature, 6.0 ft		0.3	13.72
		0.025	0.1	1.62
			0.2	4.77
			0.3	9.26
		0.035	0.1	1.33
			0.2	3.81
			0.3	7.43

(Continued)

Table 1 (Continued)

Test No.	Test Conditions	Manning's "n"	Depth (ft above Topbank)	Discharge cfs
VIII	Floodway width, 30.0 ft	0.012	0.0 (bankfull)	0.73
	Sinuosity, 1.49		0.1	3.65
	Meander-belt width, 16.0 ft		0.2	8.80
	Radius of curvature, 8.0 ft		0.3	15.35
		0.025	0.1	1.89
			0.2	5.15
			0.3	10.10
		0.035	0.1	1.50
			0.2	4.06
			0.3	7.65
IX	Floodway width, 30.0 ft	0.012	0.0 (bankfull)	0.85
	Sinuosity, 1.50		0.1	3.66
	Meander-belt width, 20.0 ft		0.2	8.92
	Radius of curvature, 10.0 ft		0.3	15.55
		0.025	0.1	2.04
			0.2	5.38
			0.3	10.14
		0.35	0.1	1.58
			0.2	4.17
			0.3	7.75
X	Floodway width, 30.0 ft	0.012	0.0 (bankfull)	0.84
	Sinuosity, 1.75		0.1	3.40
	Meander-belt width, 20.0 ft		0.2	8.39
	Radius of curvature, 8.0 ft		0.3	14.82
		0.025	0.1	1.69
			0.2	4.87
			0.3	9.40
		0.035	0.1	1.40
			0.2	3.80
			0.3	7.42

Table 2

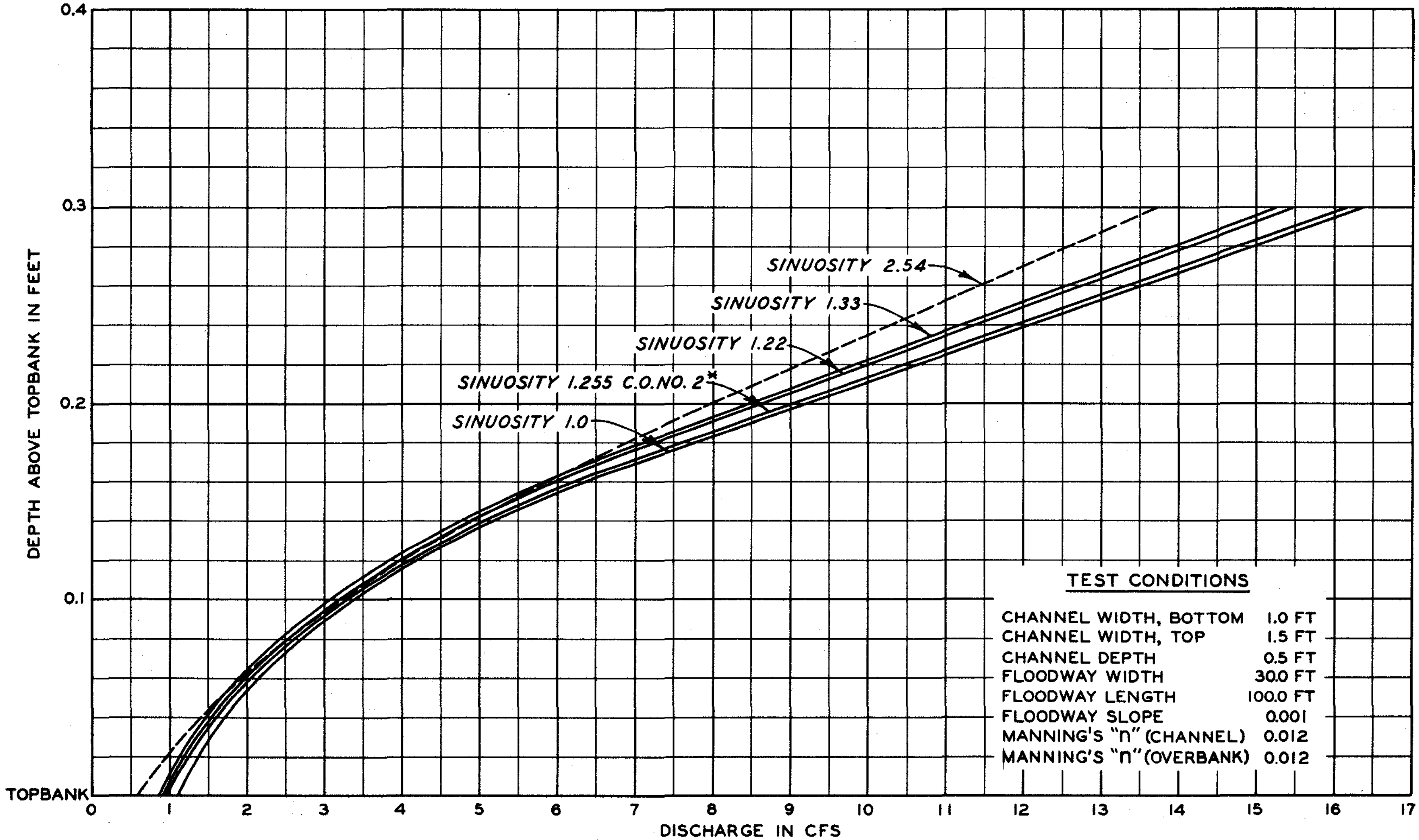
Summary of Test Data, 2-ft-wide Channel

Test No.	Test Conditions	Manning's "n"	Depth (ft above Topbank)	Discharge cfs
XI	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	2.22
	Sinuosity, 1.00		0.1	4.02
	Meander-belt width, 2.5 ft		0.2	7.73
	Radius of curvature, 0.0 ft (straight channel)		0.3	12.50
		0.025	0.1	2.81
			0.2	4.44
			0.3	7.65
		0.035	0.1	2.74
			0.2	4.28
			0.3	6.32
XII	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	1.22
	Sinuosity, 1.57		0.1	2.48
	Meander-belt width, 14.5 ft		0.2	5.03
	Radius of curvature, 6.0 ft		0.3	7.88
		0.025	0.1	1.52
			0.2	3.09
			0.3	5.46
		0.035	0.1	1.40
			0.2	2.59
			0.3	4.53
XIII	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	1.38
	Sinuosity, 1.40		0.1	2.93
	Meander-belt width, 12.34 ft		0.2	5.51
	Radius of curvature, 6.12 ft		0.3	8.58
		0.025	0.1	1.73
			0.2	3.48
			0.3	5.93
		0.035	0.1	1.55
			0.2	2.94
			0.3	4.85

(Continued)

Table 2 (Continued)

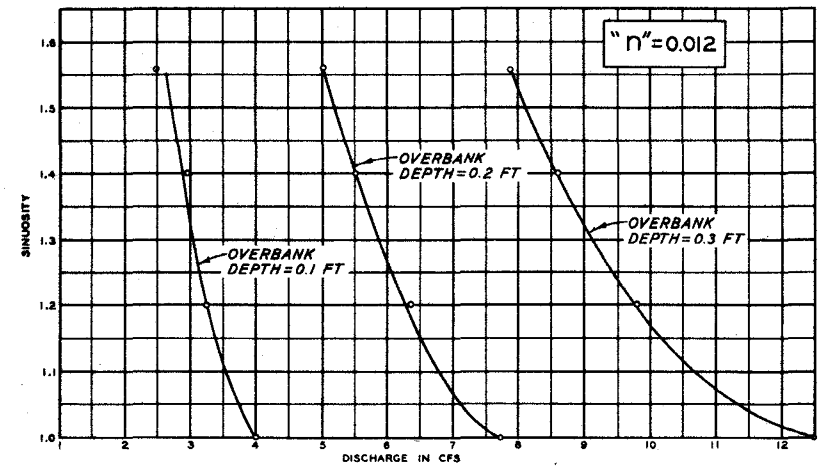
Test No.	Test Condition	Manning's "n"	Depth (ft above Topbank)	Discharge cfs
XIV	Floodway width, 16.0 ft	0.012	0.0 (bankfull)	1.55
	Sinuosity, 1.20		0.1	3.23
	Meander-belt width, 9.26 ft		0.2	6.33
	Radius of curvature, 7.01 ft		0.3	9.79
		0.025	0.1	1.96
			0.2	3.85
			0.3	6.35
		0.035	0.1	1.71
			0.2	3.05
			0.3	5.07
XV	Floodway width, 30.0 ft	0.035	0.0 (bankfull)	1.55
	Sinuosity, 1.20		0.1	2.38
	Meander-belt width, 9.26 ft		0.2	4.94
	Radius of curvature, 7.01 ft		0.3	8.65
XVI	Floodway width, 30.0 ft	0.035	0.0 (bankfull)	1.22
	Sinuosity, 1.57		0.1	1.79
	Meander-belt width, 14.5 ft		0.2	4.16
	Radius of curvature, 6.0 ft		0.3	7.86

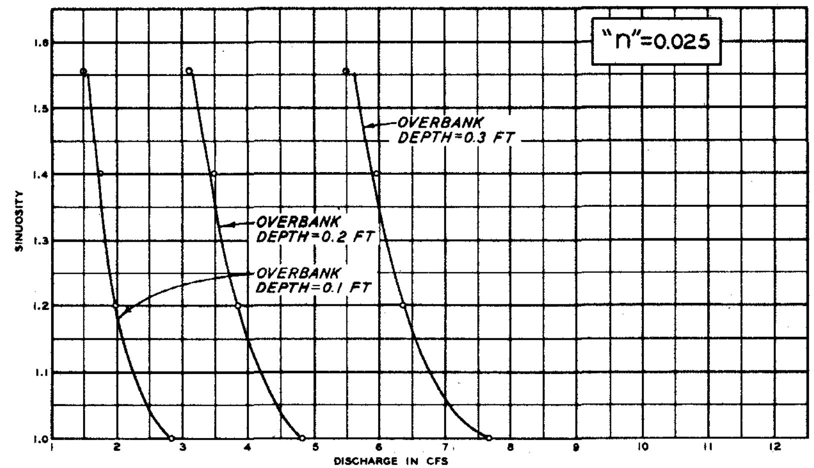


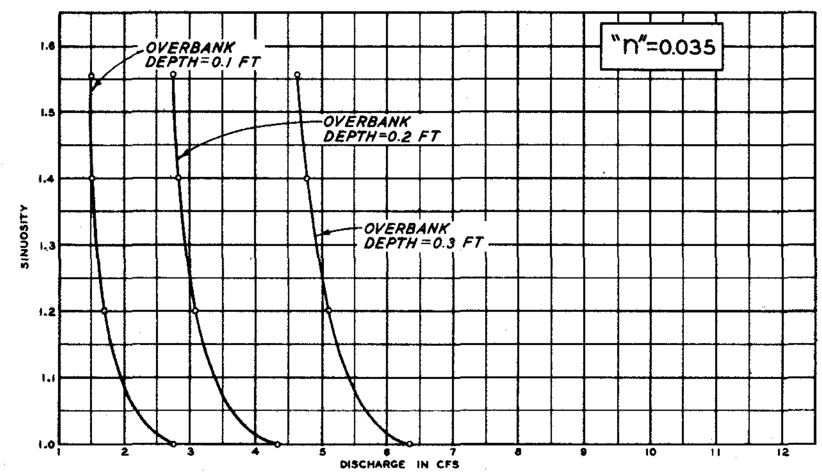
* NOTE: CUT-OFF ACROSS SECOND BEND OF CHANNEL

DEPTH-DISCHARGE RELATIONSHIP
FOR VARIOUS CHANNEL SINUOSITIES
1-FT CHANNEL "n" (OVERBANK) = 0.012

PLATE 2





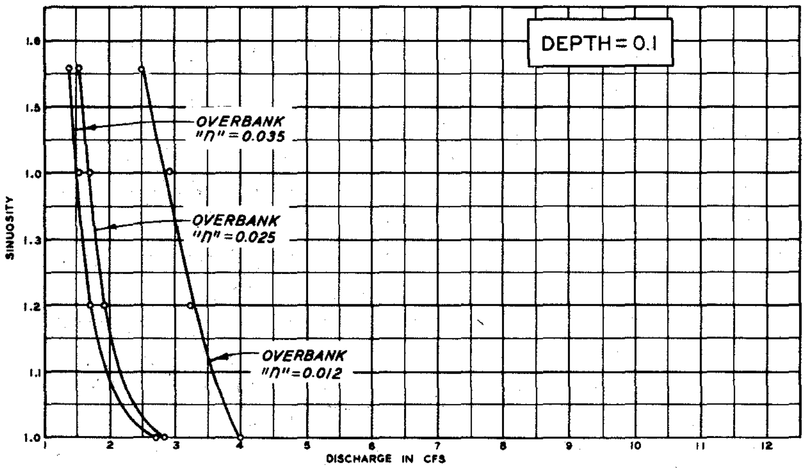


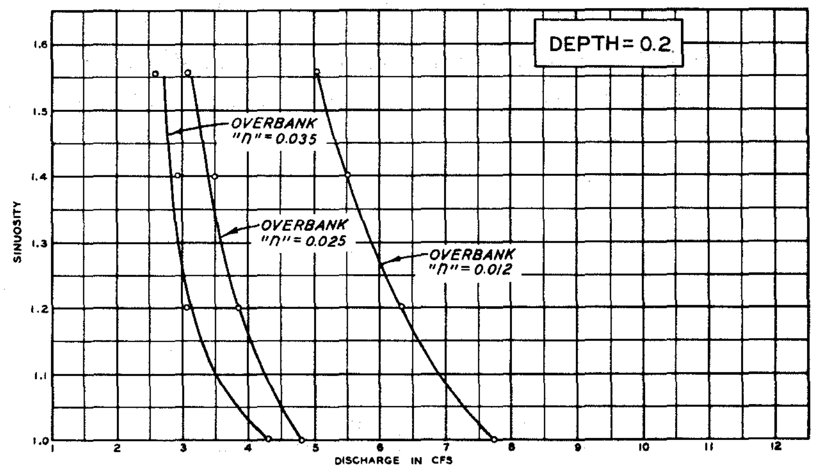
TEST CONDITIONS

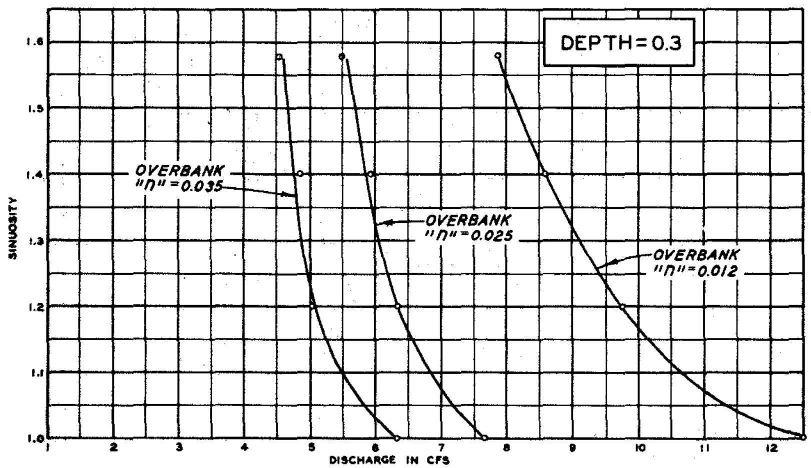
CHANNEL WIDTH, BOTTOM	2.0 FT
CHANNEL WIDTH, TOP	2.5 FT
CHANNEL DEPTH	0.5 FT
FLOODWAY WIDTH	16.0 FT
FLOODWAY LENGTH	100.0 FT
FLOODWAY SLOPE	0.001
MANNING'S "n" (CHANNEL)	0.012

SINUOSITY-DISCHARGE RELATIONSHIPS FOR VARIOUS OVERBANK FLOW DEPTHS

2-FT-WIDE CHANNEL







TEST CONDITIONS

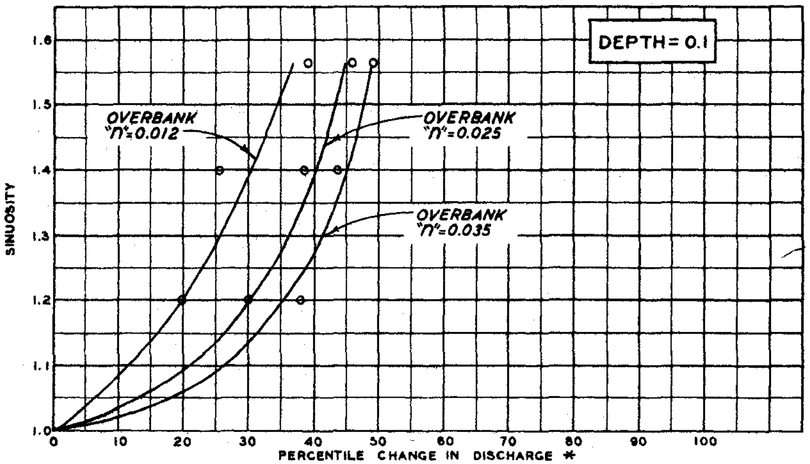
CHANNEL WIDTH, BOTTOM	2.0 FT
CHANNEL WIDTH, TOP.	2.5 FT
CHANNEL DEPTH	0.5 FT
FLOODWAY WIDTH	16.0 FT
FLOODWAY LENGTH	100.0 FT
FLOODWAY SLOPE	0.001
MANNING'S "n" (CHANNEL)	0.012

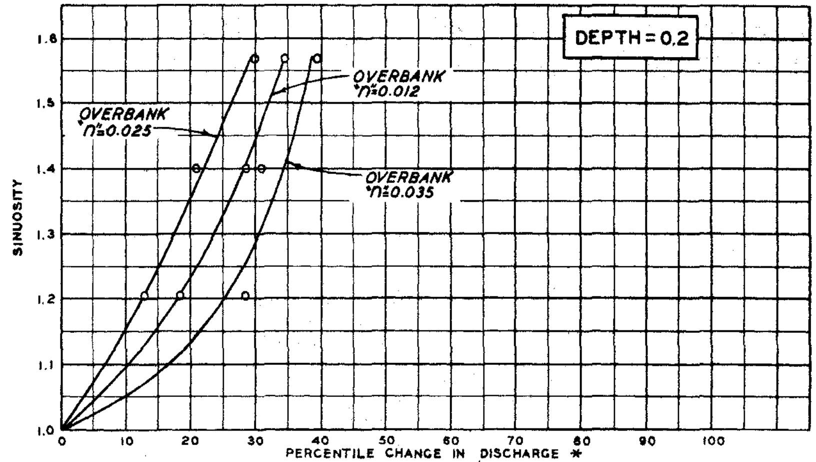
SINUOSITY–DISCHARGE RELATIONSHIPS FOR VARIOUS OVERBANK ROUGHNESSES

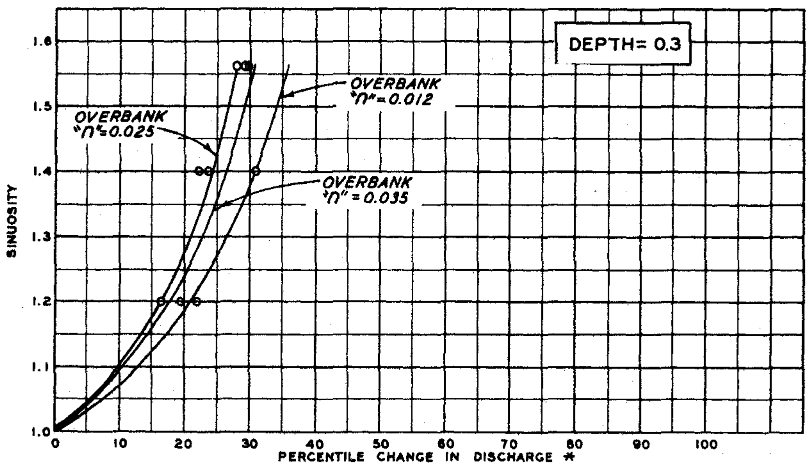
2-FT-WIDE CHANNEL, OVERBANK FLOW

PLATE 3

PLATE 4



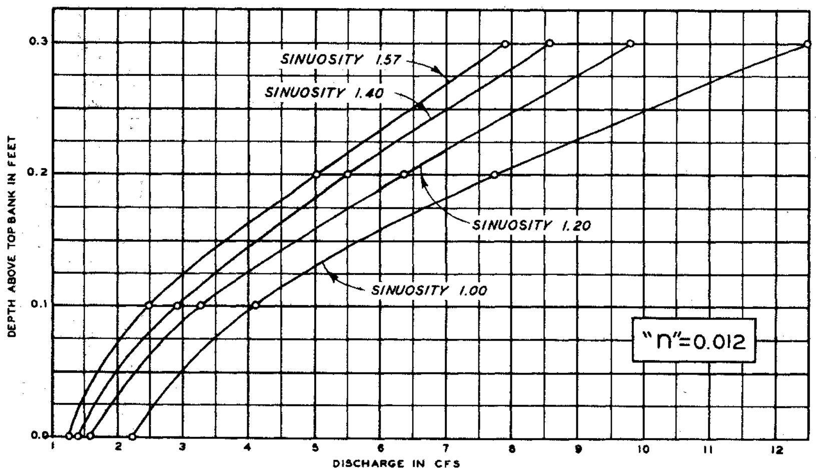


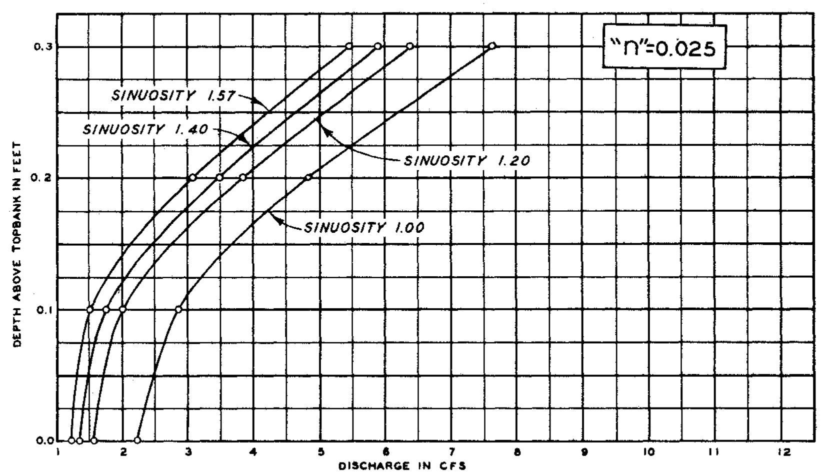


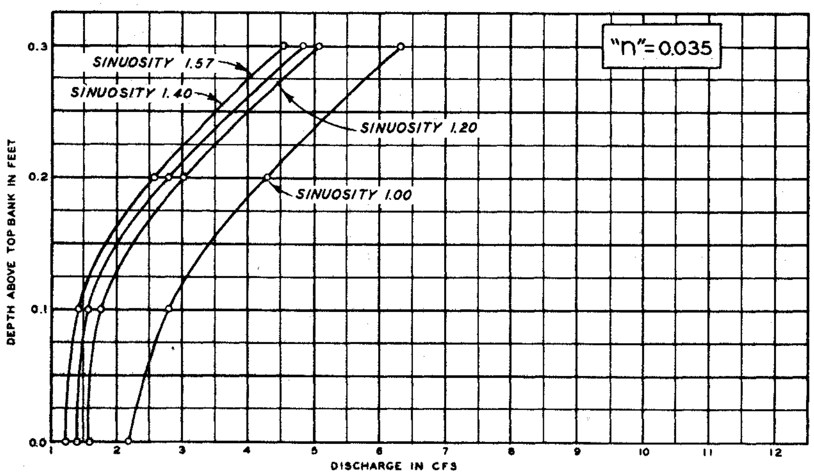
$$*Q_r = \frac{\text{Q STRAIGHT CHANNEL} - \text{Q SINUOUS CHANNEL}}{\text{Q STRAIGHT CHANNEL}}$$

SINUOSITY-DISCHARGE RATIO RELATIONSHIPS FOR VARIOUS OVERBANK ROUGHNESSES

2-FT-WIDE CHANNEL, OVERBANK FLOW





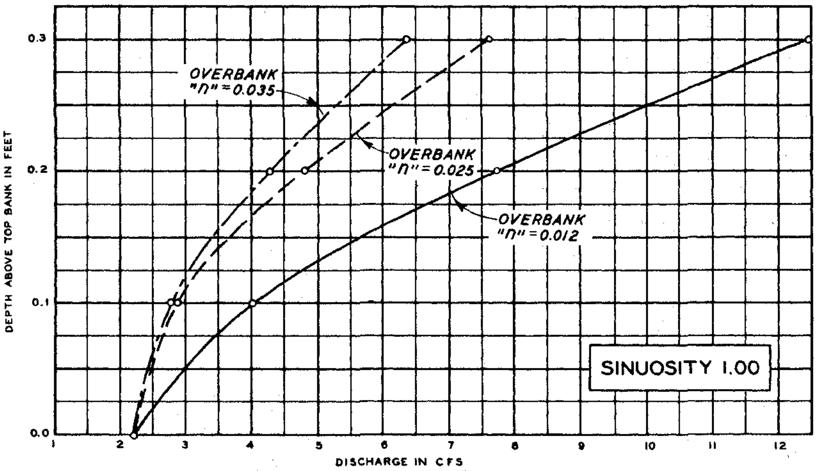


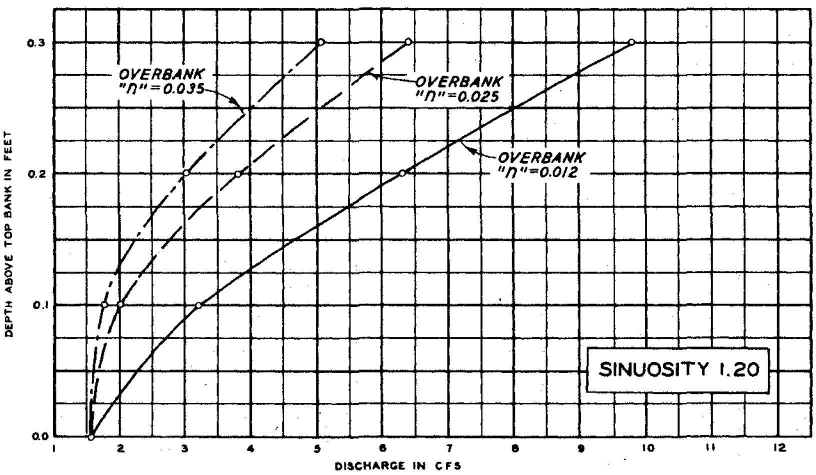
TEST CONDITIONS

CHANNEL WIDTH, BOTTOM	2.0 FT
CHANNEL WIDTH, TOP	2.5 FT
CHANNEL DEPTH	0.5 FT
FLOODWAY WIDTH	16.0 FT
FLOODWAY LENGTH	100.0 FT
FLOODWAY SLOPE	0.001
MANNING'S "n" (CHANNEL)	0.012

DEPTH-DISCHARGE RELATIONSHIPS FOR VARIOUS CHANNEL SINUOSITIES

2-FT-WIDE CHANNEL



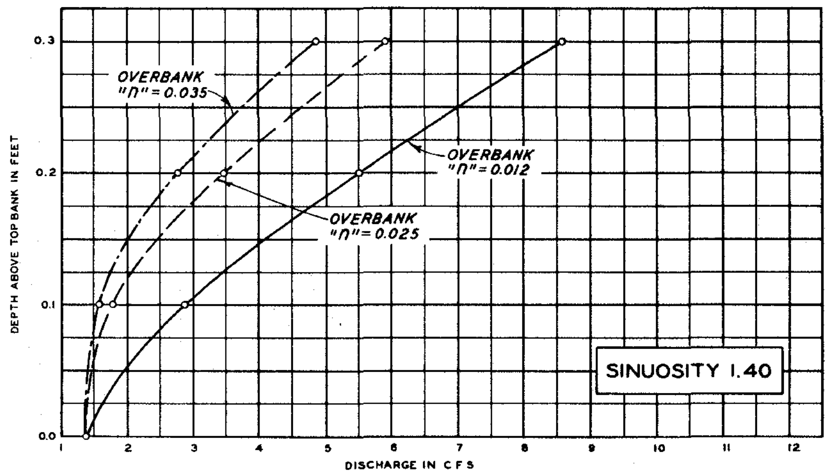


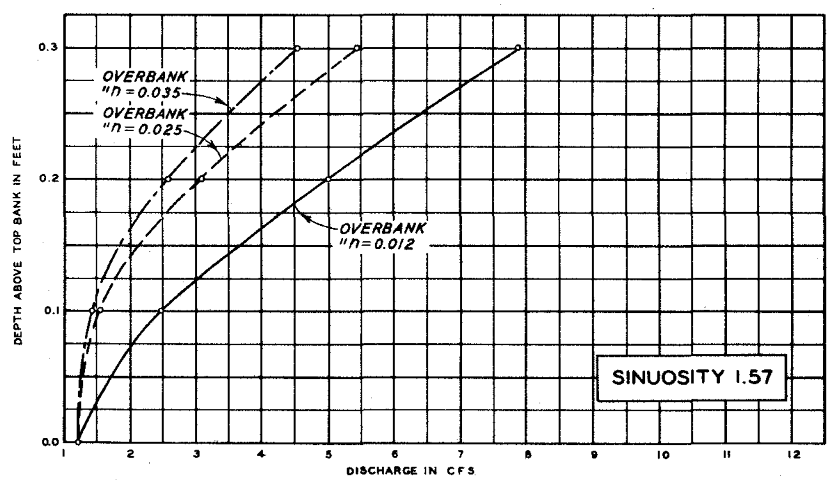
TEST CONDITIONS

CHANNEL WIDTH, BOTTOM	2.0 FT
CHANNEL WIDTH, TOP	2.5 FT
CHANNEL DEPTH	0.5 FT
FLOODWAY WIDTH	16.0 FT
FLOODWAY LENGTH	100.0 FT
FLOODWAY SLOPE	0.001
MANNING'S "n" (CHANNEL)	0.012

DEPTH-DISCHARGE RELATIONSHIPS FOR VARIOUS OVERBANK ROUGHNESSES

2-FT-WIDE CHANNEL SINUOSITIES 1.00 AND 1.20



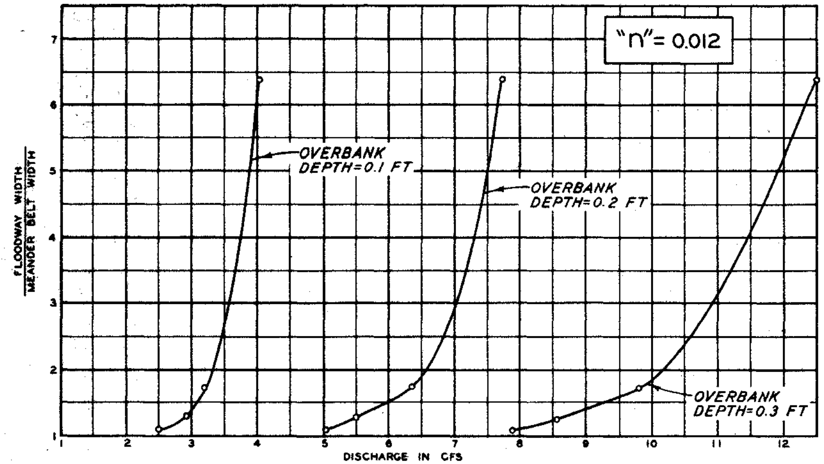


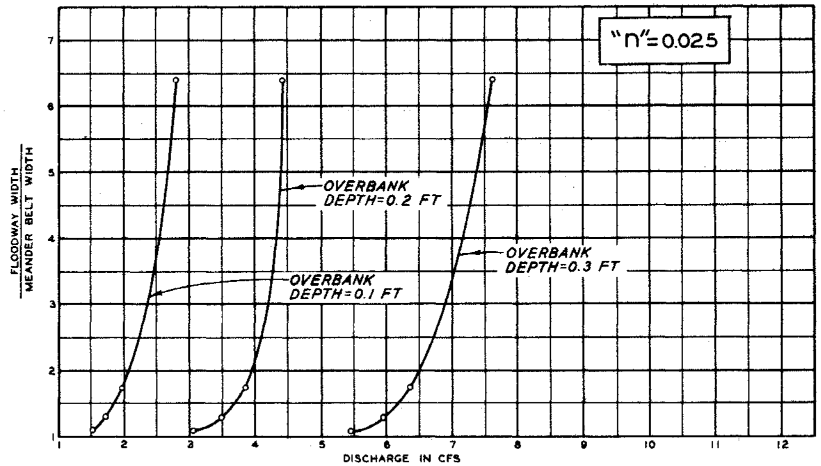
TEST CONDITIONS

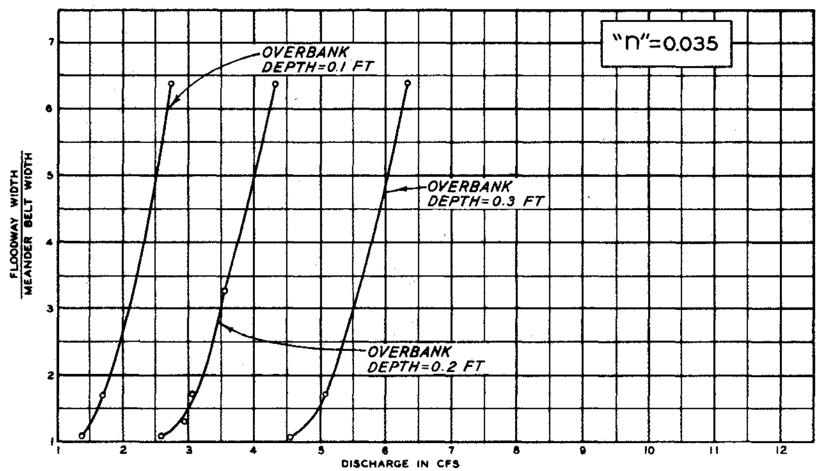
CHANNEL WIDTH, BOTTOM	2.0 FT
CHANNEL WIDTH, TOP	2.5 FT
CHANNEL DEPTH	0.5 FT
FLOODWAY WIDTH	16.0 FT
FLOODWAY LENGTH	100.0 FT
FLOODWAY SLOPE	0.001
MANNING'S "n" (CHANNEL)	0.012

DEPTH-DISCHARGE RELATIONSHIPS FOR VARIOUS OVERBANK ROUGHNESSES

2-FT-WIDE CHANNEL SINUOSITIES 1.40 AND 1.57





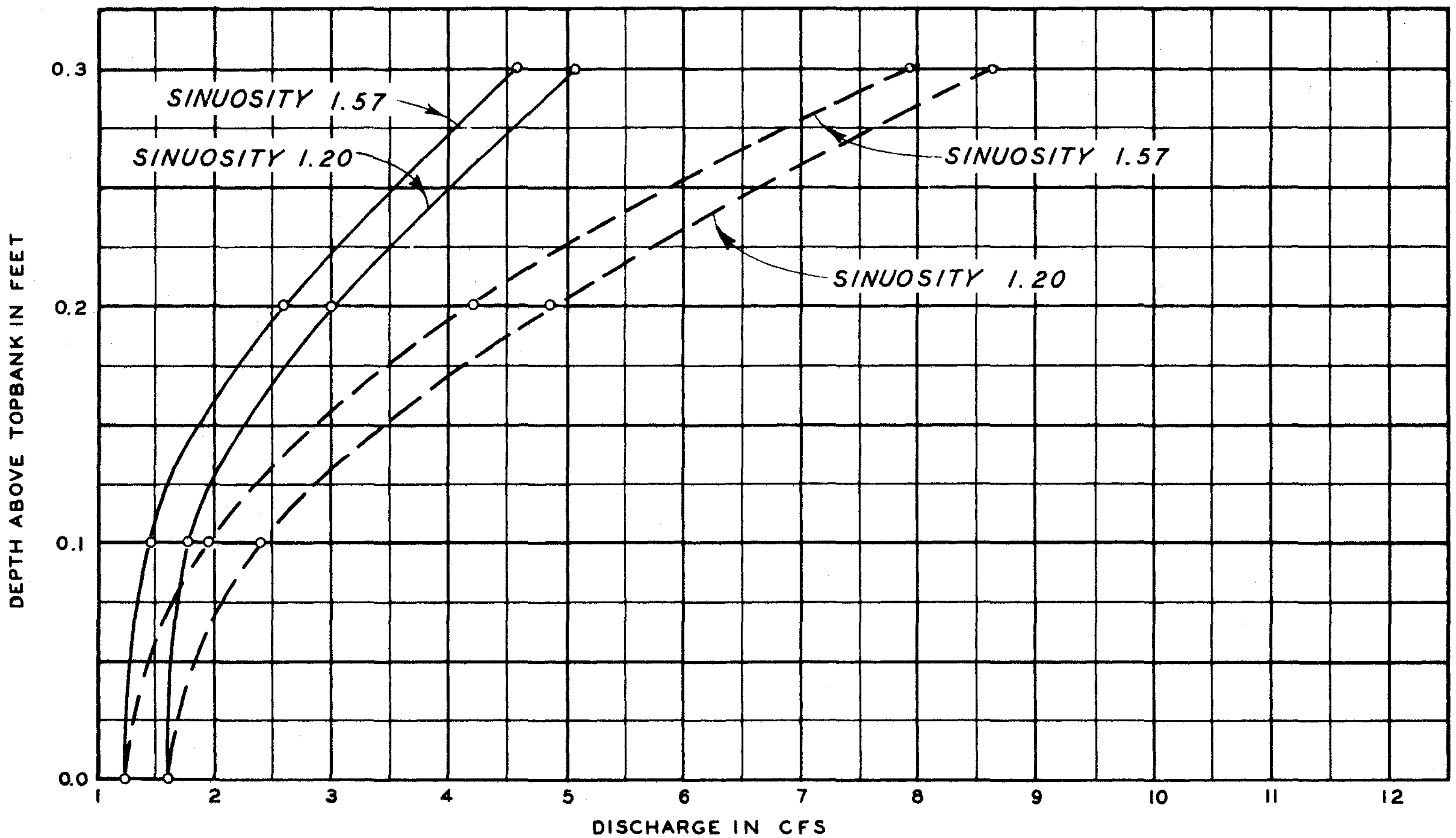


TEST CONDITIONS

CHANNEL WIDTH, BOTTOM	2.0 FT
CHANNEL WIDTH, TOP	2.5 FT
CHANNEL DEPTH	0.5 FT
FLOODWAY WIDTH	16.0 FT
FLOODWAY LENGTH	100.0 FT
FLOODWAY SLOPE	0.001
MANNING'S "n" (CHANNEL)	0.012

FLOODWAY WIDTH, MEANDER-BELT WIDTH RATIO DISCHARGE RELATIONSHIP FOR VARIOUS OVERBANK FLOW DEPTHS

2-FT-WIDE CHANNEL



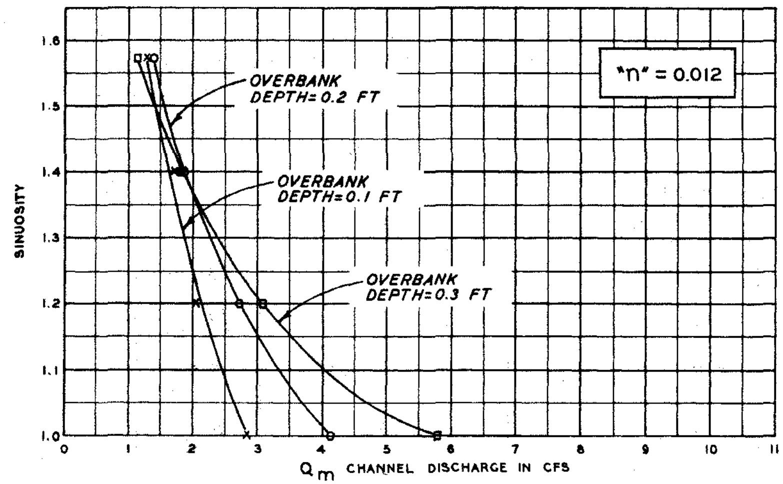
LEGEND

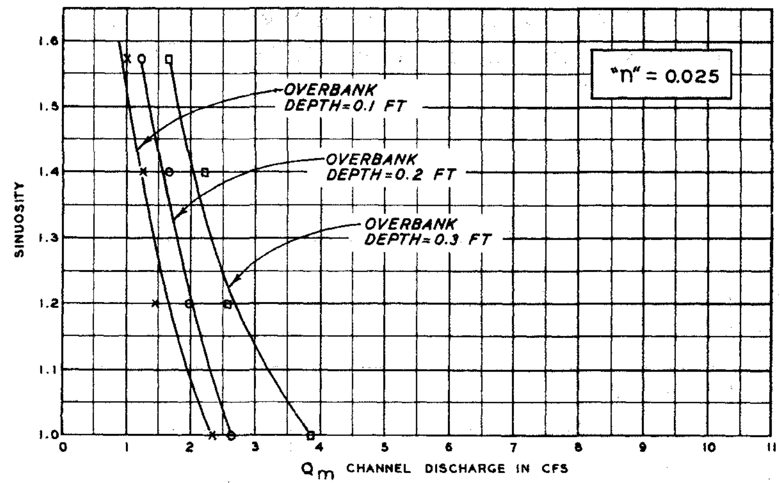
—— 16-FT FLOODWAY WIDTH

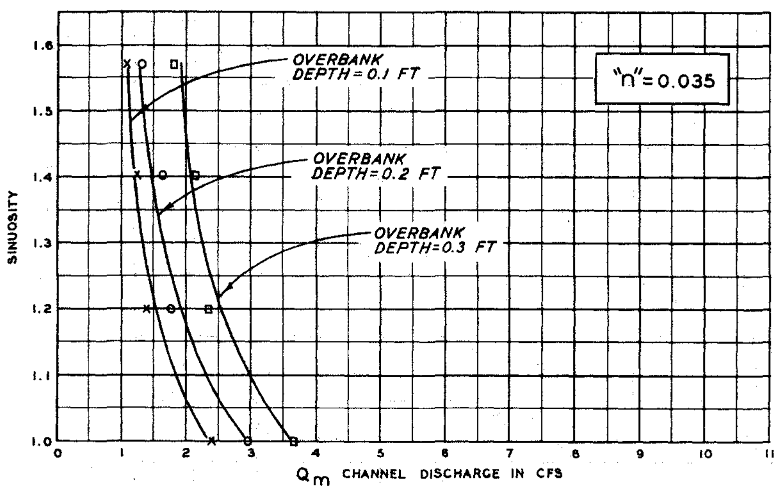
– – – 30-FT FLOODWAY WIDTH

DEPTH-DISCHARGE RELATIONSHIP
FOR 16-FT AND 30-FT FLOODWAY WIDTH
2-FT CHANNEL, "n" (OVERBANK) = 0.035

PLATE 10

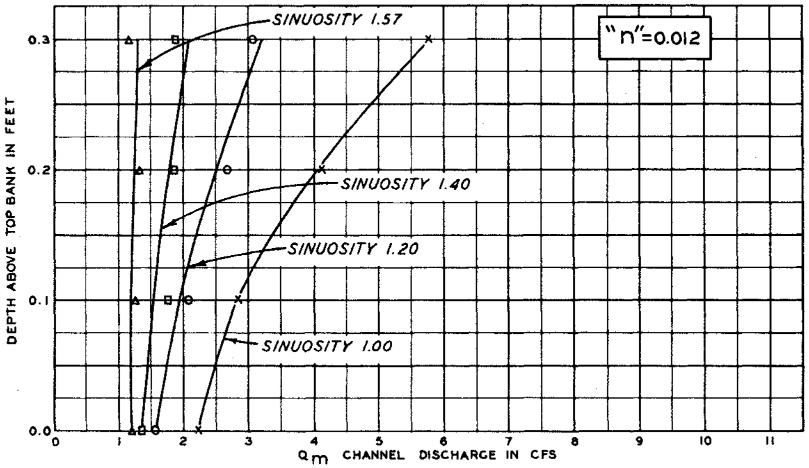


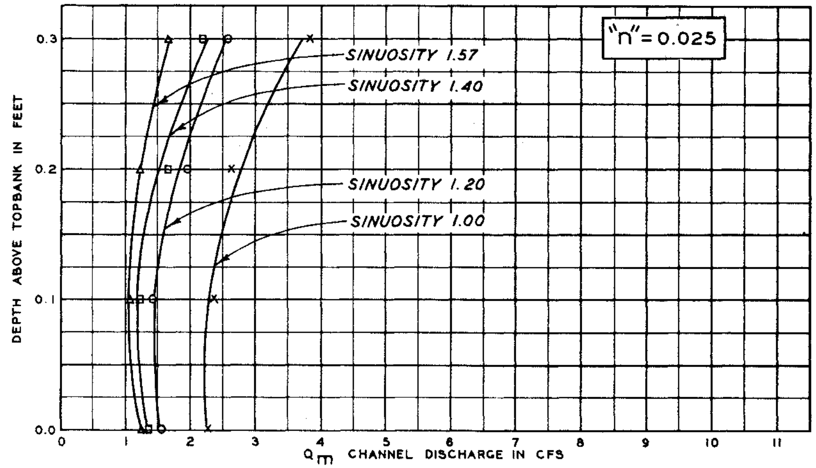


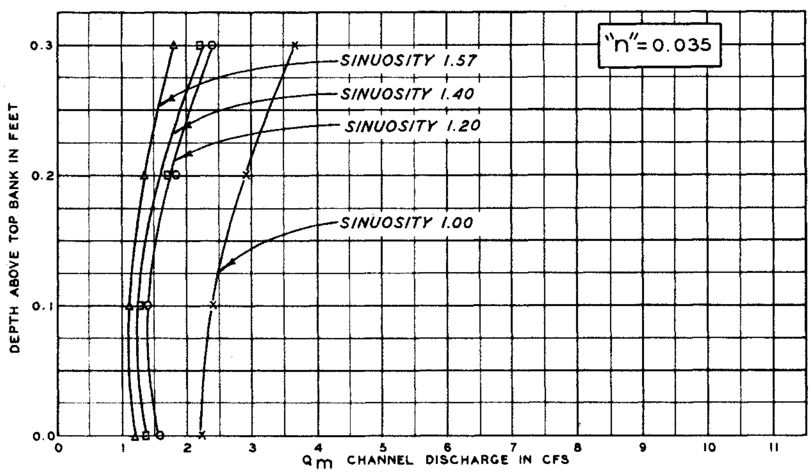


SINUOSITY-CHANNEL DISCHARGE RELATIONSHIPS FOR VARIOUS OVERBANK FLOW DEPTHS

2-FT-WIDE CHANNEL



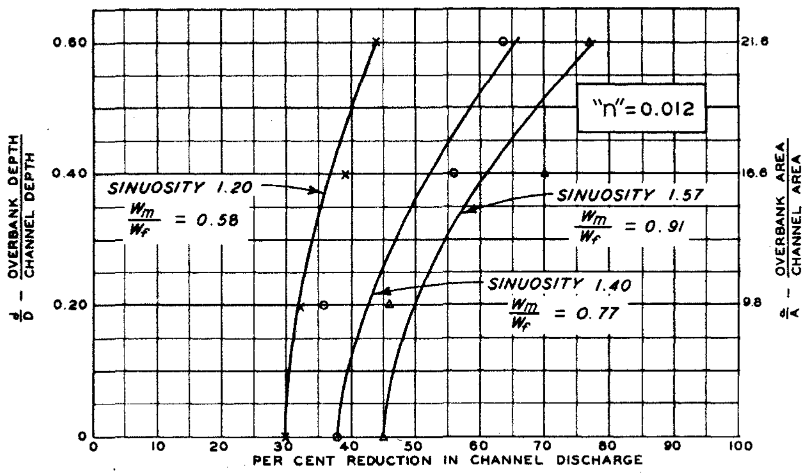


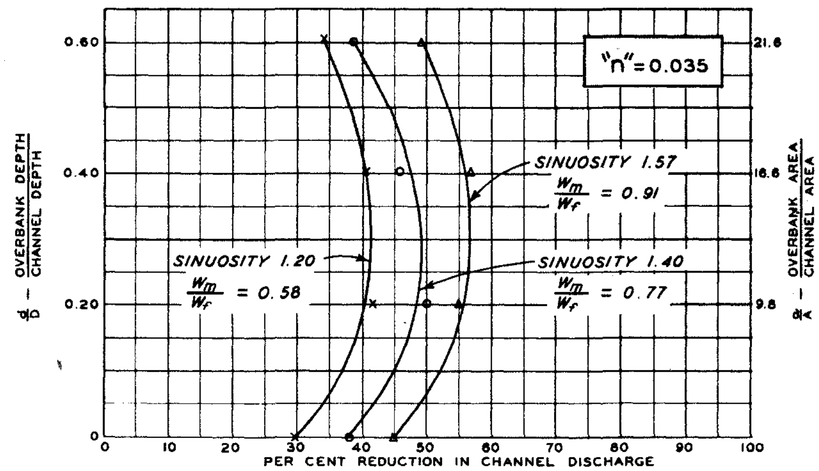


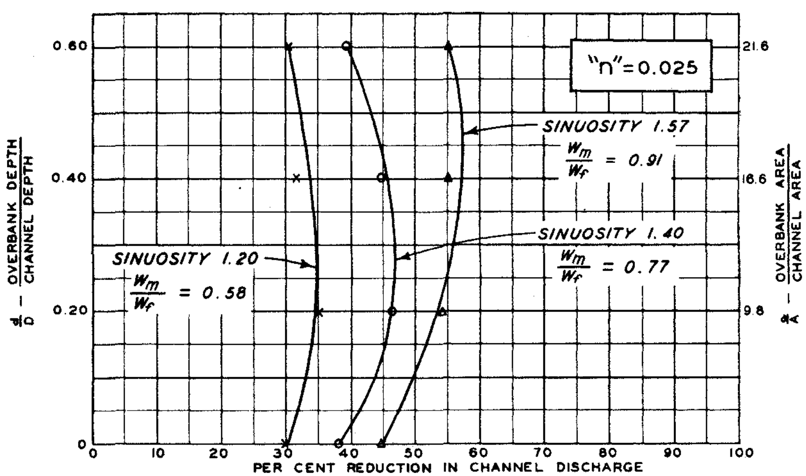
DEPTH–CHANNEL DISCHARGE RELATIONSHIPS FOR VARIOUS CHANNEL SINUOSITIES

2-FT–WIDE CHANNEL

PLATE 11







W_m = WIDTH OF MEANDER BELT
W_f = WIDTH OF FLOOD PLAIN

REDUCTION IN CHANNEL DISCHARGE RELATED TO RATIO OF OVERBANK AND CHANNEL FLOW DEPTHS AND AREAS

2-FT-WIDE CHANNEL